e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:04/Issue:07/July-2022 Impact Factor- 6.752 www.irjmets.com

DESIGN AND MODELLING OF FRONTAL CRASH ANALYSIS OF CAR

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ABSTRACT

Every day Car accidents are happening. Most troublesome situations are occurred to the drivers that they can avoid such. The statistics shows that ten thousand dead and hundreds of thousands to million wounded each year. Hence, improvement in the safety of automobiles is prerequisite to decrease the numbers of accidents. In automobile design, crash and structural analysis are the two most important engineering processes in developing a high quality vehicle. Computer simulation technologies have greatly enhanced the safety, reliability, and comfort, environmental and manufacturing efficiency of today's automobiles. This significant achievement was realized with the advanced software and powerful computers that have been available in the last twenty years. The primary concern for drivers and passengers is safety. Governments have responded to this key concern and expectation with an increasing number of regulations.

Keywords: Analysis, Design, Modelling, Materials, Investigation, Research.

I. INTRODUCTION

Although the details may vary slightly from country to country, the fundamental requirements are almost similar. A vehicle is expected to provide adequate protection to drivers and passengers in a not so serious accident. To protect the occupants of a car, there are many new tangible safety features such as airbags; ABS control brakes, traction control. A less tangible feature that cannot easily be seen by drivers and passengers is the crash response behavior. In a well-designed automobile, the car body and various components are the protective layer for the occupants of the vehicle. They serve as the crumpling zone to absorb the energy of impact. The traditional approach involves multiple iterations of design, prototype and crash tests. The process is time consuming and expensive. The availability of high performance computers and crash simulation software has revolutionized the process. Instead of relying on experimental validations, the safety design process is supplemented with computer simulation to evaluate the design. Since the inception of crash simulation, the product cycle of a new automobile has been reduced by half and the resultant vehicle is safer, better and more comfortable.

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II. LITERATURE REVIEW

Passenger cars are a major mode of transport in the developed as well as in the developing countries. Therefore the accidents caused due to passenger cars are also significantly on the rise. In all types of crash accidents, about 30 % of the total numbers of accidents are frontal crash case. Therefore, measures to improve passenger vehicle passive safety performance in crash to reduce injury and death of passengers during a crash to the maximum has become an important subject of research. The frontal beam is an integral partof the crumple zones which form the front energy absorbing area. They are one of the structural members which will absorb high energies in frontal impact, so that impact energy won't transmit to passengers.

Andrew Hickey et al. [1] has performed a quasi-static simulation, to simulate the car crash by using finite element method (FEM). Safety of passengers is one of the most important design considerations in the automobile community. Therefore, a crash test is a crucial step to validate the car design. Experimental crash tests results in higher cost, and acquired data might not be correct. Therefore, a numerical modelling and the simulations are used for studying a car crash than to perform experimental testing. Hence, a powerful numerical tool, FEM plays acrucial role in crash test simulations.

C. Sadhasivam et al. [2] has performed a detail car body mode analysis and stress analysis based on 3D LS-DYNA in ANSYS. Modal analysis has been performed to know the natural frequencies and mode shapes of a car body structure. Vibration and crash analysis of the car body is performed, which includes dynamic, static and crash analysis. Most of the automobile manufacturers generally prefer lightweight materials to reduce weight and these include composites, aluminium, magnesium or new types of high strength steels. These materials have a limited strength or ductility, in case of rupture which is a most common seen phenomenon during a crash accident. Material joining failure is also one of the consequences on the vehicle crashworthiness. In a car crash, front-part of the automobile structure absorbs a lot of impact and undergoes plastic deformation. Most of the vehicles are designed to increase the absorption efficiency, to enhance the safety of passengers and reliability of the vehicle. Crashworthiness of different parts of a vehicle needs to be evaluated at the initial stage of the vehicle design only. The dynamic behaviour of a structural member is always different from the static behaviour, therefore crashworthiness of the vehicle can be known by impact analysis. Hence, it is necessary to check the crash ability of car structure for both safety and fuel economy. The two ways of ensuring safety are by performing a crash test of a car or by simulating the crash analysis of the modelled car structure in analysis software.

Byeong Sam Kim et al. [3] has performed a crash analysis of sub frame and upper body for neighborhood electric vehicle (NEV). NEV's front platform assembly behaviour was simulated in LS-DYNA and results were observed when it is subjected to a frontal car crash. The safety of passengers at low cost reduction has been researched. When a vehicle crashes, the passengers inside the vehicle must be free from injury and the vehicle must be able to withstand impact loads. In crash accidents, capability of the vehicle structure to absorb the energy can be defined as crashworthiness. The vehicle structure should be designed to withstand higher speed and the passengers should not experience a net deceleration.

Lin et al. [4] had performed the computer simulation of acar crash analysis. They have analysed two crash situations:a higher speed car crashing into a wall and a high velocity car crashing into a static car. The objective of the research was to know the sources which can harm the driver and the passengers when car accidents occur and to create a model of a bumper for knowing its potentiality to withstand impact loads on it. The Simulations on bumper are performed to assure that the bumper design meets the safety requirements.

Praveen et al. [6] has performed a car crash analysis in non-linear transient dynamics. In the crash test, frontal collision and sideways collision analysis is performed to know deformations of the car. Crashworthiness of the car simulations is performed in Finite Element Analysis (FEA). The chassis frame takes the loads of a heavy vehicle, its function is to carry the loads on the vehicle safely for each operating condition. The frame of chassis should be able to support different chassis components and vehicle structure. Chassis frame should withstand both static loads and dynamic loads without any distortion or deflection in the vehicle. The frontal collision and side collision conditions are tested on the generated model, the total deformations and stresses developed are determined.

III. MATERIALS AND METHODOLOGY

Properties of Car Body Material Structural steel

It is a category of steel used as a construction material for making structural steel shapes. A structural steel shapes a profile, formed with a specific cross section and following certain standards for chemical composition and mechanical properties.

Objectives and Scopes

- To analyze a mechanical properties on front part of car body.

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- To analyze on mechanical properties focus stress, strain analysis.
- To modelling the actual dimension of the car body in to the SOLIDWORKS software and analyze by using ANSYS software.
- To investigate different materials car body based on their geometry and other parameters that influence the compatibility of car body.
- To evaluate failure mechanism of the car body.
- To study the load distribution on the car body either it is uniformly distributes to all the part during the analysis.

Modelling Solid works:

Solid works currently markets several versions of the Solid Works CAD software in addition to Drawings, a collaboration tool, and DraftSight, a 2D CAD product. Solid Works was headed by John McEleney from 2001 to July 2007 and jeff Ray from 2007 to January 2011. The current CEO is GianPaolo Bassi from Jan 2015. Gian Paolo Bassi replaces Bertrand Sieot, who is promoted vice president sales of Dassault systems Value Solution sales channel.

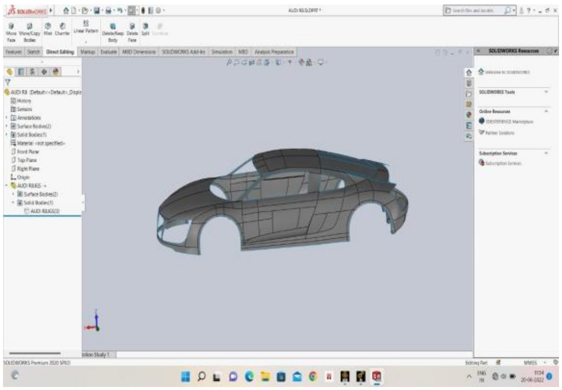


Fig: Model car body

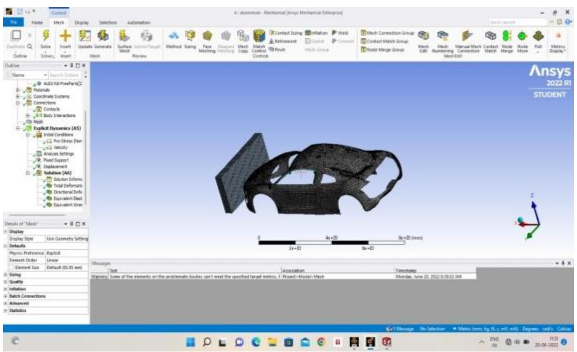
ANALYSIS OF CAR BODY

EXPLICIT DYNAMIC ANALYSIS USING ANSYS

Explicit refer to two types of time integration methods used to perform dynamic simulations.

Explicit time integration is more accurate and efficient for simulations involving

- Shock wave propagation
- Large deformations and strains
- Non-linear material behaviour
- Complex contact
- Fragmentation
- Non-linear buckling. Typical applications are drop tests and impact and penetration. ANSYS Explicit Dynamics analysis software provides simulation technology to help simulate structural performance long before manufacture.



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ANALYSIS OF CAR BODY MADE BY ALUMINUM B390 ALLOY Properties:

- Density: 2.8e-006 kg/mm^-3
- Young's modulus: 7.1e+005 MPa
- Poisson's ratio: 0.33
- Bulk modulus: 6.9608e+005 MPa
- Shear modulus: 2.6692e+005 MPa
- Compressive Yield Strength: 250 MPa
- Tensile Yield Strength: 250 MPa
- Tensile Ultimate Strength: 460 MP

At speed is 90 kmph

TOTAL DEFORMATION

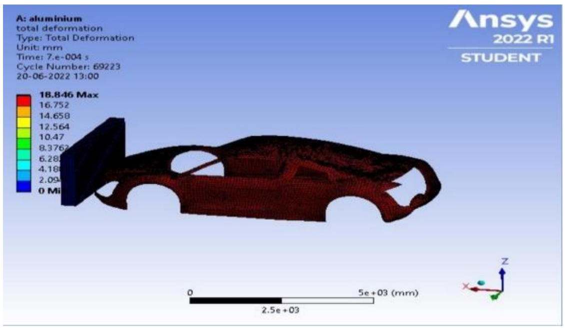
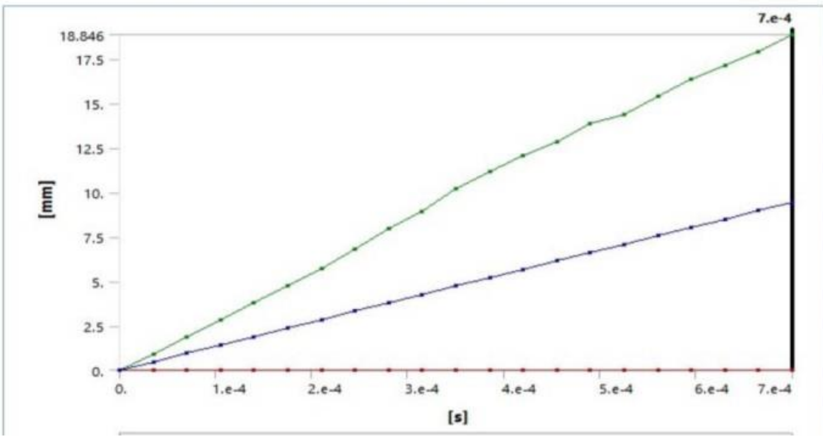


Fig: Total deformation



Graph: Total deformation

DIRECTIONAL DEFORMATION

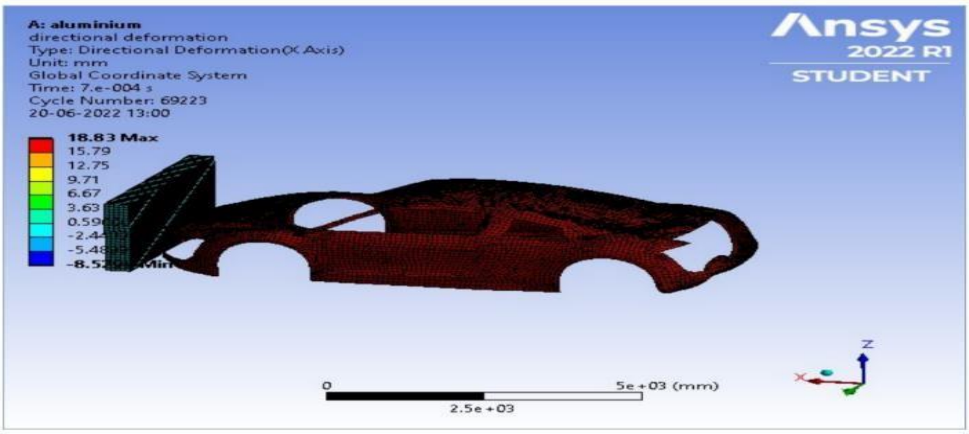


Fig: Directional deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.1755e-038	0.	0.	0.
3.5e-005	-0.10544	0.89351	0.4721
7.0002e-005	-0.37393	1.8702	0.94413
1.05e-004	-1.0298	2.8366	1.4161
1.4001e-004	-1.5793	3.7843	1.8881
1.7501e-004	-2.1193	4.7391	2.36
2.1001e-004	-2.5754	5.676	2.8319
2.45e-004	-3.0421	6.7829	3.3037
2.8e-004	-3.5983	7.9111	3.7755
3.15e-004	-3.9727	8.9199	4.2474
3.5001e-004	-4.3918	10.198	4.7193
3.8501e-004	-4.8375	11.144	5.1911
4.2001e-004	-5.234	12.017	5.6629
4.55e-004	-5.7053	12.826	6.1345
4.9e-004	-6.0193	13.867	6.606
5.25e-004	-6.5618	14.354	7.0774
5.6001e-004	-7.0432	15.39	7.5487
5.9501e-004	-7.3676	16.361	8.02
6.3001e-004	-7.9039	17.105	8.4912
6.65e-004	-8.0216	17.892	8.9622
7.e-004	-8.5299	18.83	9.4334

EQUIVALENT ELASTIC STRAIN

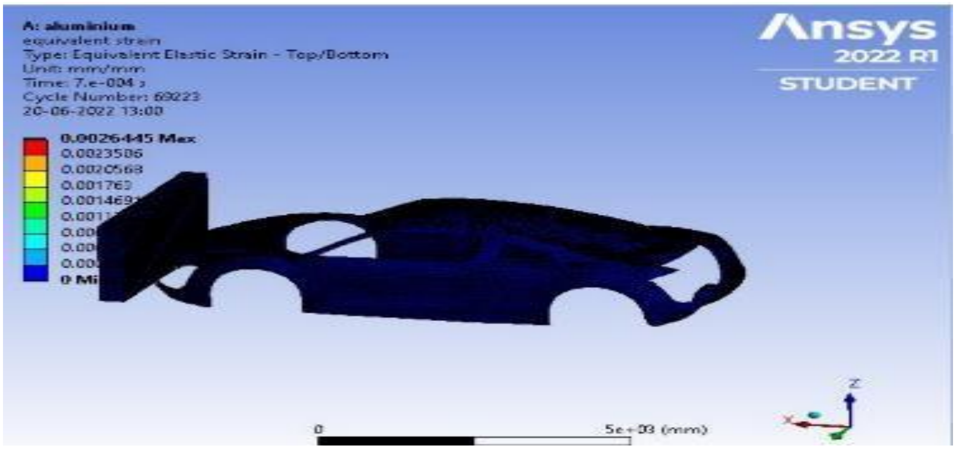
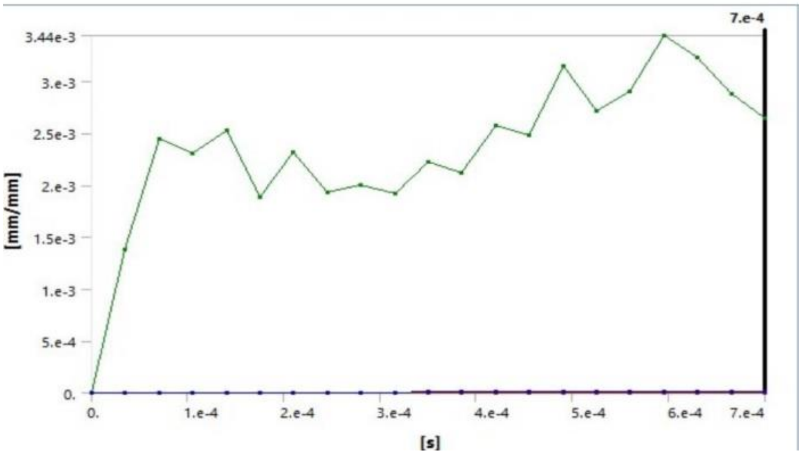


Fig: Elastic strain

Table: Elastic strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.1755e-038		0.	0.
3.5e-005		1.385e-003	9.9148e-007
7.0002e-005		2.4435e-003	1.761e-006
1.05e-004		2.3027e-003	2.3762e-006
1.4001e-004		2.5329e-003	2.9195e-006
1.7501e-004		1.8839e-003	3.7217e-006
2.1001e-004		2.3163e-003	4.181e-006
2.45e-004		1.9292e-003	4.6737e-006
2.8e-004		1.9954e-003	5.2407e-006
3.15e-004		1.9198e-003	5.5871e-006
3.5001e-004	0.	2.2289e-003	6.6537e-006
3.8501e-004		2.1185e-003	6.976e-006
4.2001e-004		2.5693e-003	8.0895e-006
4.55e-004		2.4806e-003	8.259e-006
4.9e-004		3.1425e-003	9.7246e-006
5.25e-004		2.7194e-003	9.6581e-006
5.6001e-004		2.9064e-003	1.0109e-005
5.9501e-004		3.44e-003	1.1218e-005
6.3001e-004		3.2291e-003	1.1902e-005
6.65e-004		2.8768e-003	1.2122e-005
7.e-004		2.6445e-003	1.1945e-005



Graph: Elastic strain

At speed is 60kmph:

TOTAL DEFORMATION

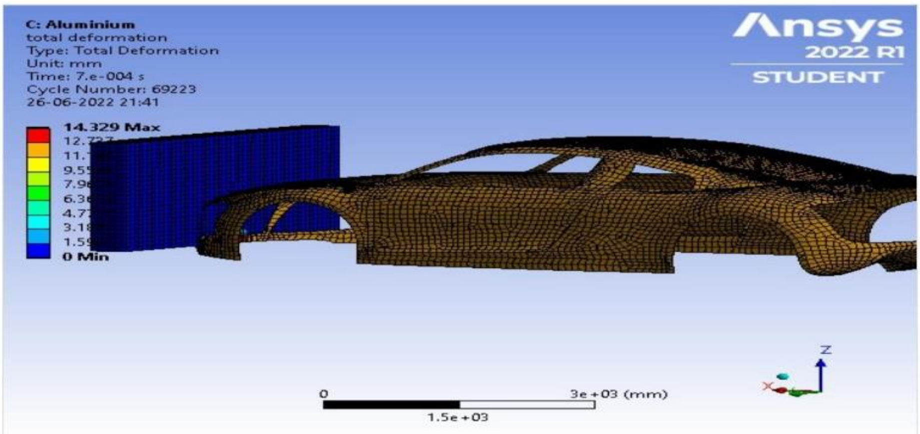


Fig: Total deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.1755e-038	0.	0.	0.
3.5001e-005		0.75041	0.32118
7.0003e-005		1.3408	0.64246
1.05e-004		2.0129	0.96389
1.4001e-004		2.7803	1.2855
1.7501e-004		3.629	1.6072
2.1001e-004		4.4566	1.9291
2.45e-004		5.2425	2.2513
2.8e-004		6.023	2.5738
3.15e-004		6.8074	2.8968
3.5001e-004		7.5822	3.2202
3.8501e-004		8.3478	3.544
4.2e-004		9.0969	3.8682
4.55e-004		9.8065	4.1931
4.9e-004		10.471	4.5187
5.2501e-004		11.141	4.845
5.6001e-004		11.809	5.1721
5.9501e-004		12.418	5.5002
6.3e-004		13.006	5.8292
6.65e-004		13.62	6.1592
7.e-004		14.329	6.4904

Fig: Total deformation

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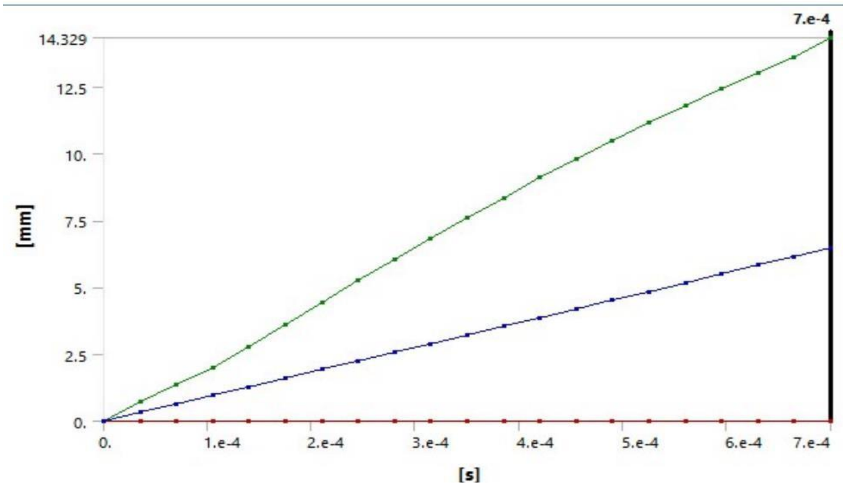

Fig: Total deformation

DIRECTIONAL DEFORMATION

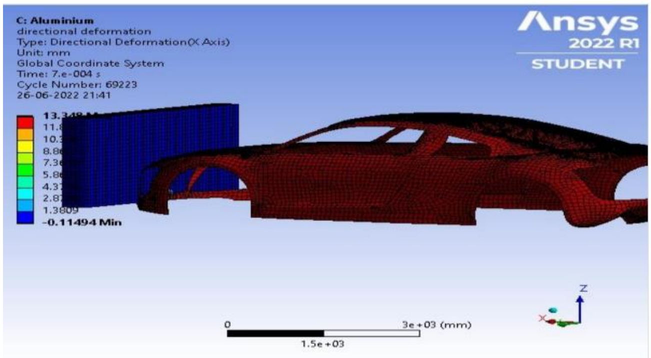

Fig: Directional deformation

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.1755e-038	0.	0.	0.
3.5001e-005	-8.2795e-003	0.74606	0.32117
7.0003e-005	-3.4742e-002	1.3026	0.64242
1.05e-004	-0.10768	1.8948	0.96376
1.4001e-004	-0.14421	2.5633	1.2852
1.7501e-004	-0.15014	3.3716	1.6068
2.1001e-004	-0.18594	4.1677	1.9285
2.45e-004	-0.26936	4.92	2.2503
2.8e-004	-0.36466	5.6636	2.5725
3.15e-004	-0.42598	6.4136	2.895
3.5001e-004	-0.45141	7.1522	3.2177
3.8501e-004	-0.27964	7.8676	3.5407
4.2e-004	-3.5094e-002	8.559	3.864
4.55e-004	-4.5458e-002	9.2258	4.1876
4.9e-004	-5.109e-002	9.8435	4.5116
5.2501e-004	-6.1382e-002	10.454	4.8361
5.6001e-004	-6.8611e-002	11.068	5.1611
5.9501e-004	-8.0965e-002	11.628	5.4865
6.3e-004	-8.9211e-002	12.178	5.8125
6.65e-004	-0.1023	12.762	6.1392
7.e-004	-0.11494	13.348	6.4665

Fig: Directional deformation

From the above results shows that performance of three different materials

- Comparing the maximum total deformation of Aluminum B390 alloy is 18.846mm and structural steel is 20.97mm and the minimum total deformation of Aluminum B390 alloy is 0mm and structural steel is 0mm.
- Comparing the maximum directional deformation of Aluminum B390 alloy is 18.83mm and structural steel is 19.866mm.
- On comparing these results it is found that Aluminium B390 alloy is the best performance because deformation is less.
- Comparing the maximum equivalent stress of Aluminium B390 alloy is 180.03Mpa and structural steel is

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1325.3 Mpa.

- On comparing these results it is found that Aluminum B390 alloy is best performance against deformation and initial resistance is high compare to structural steel. So safety was high using this material in making car body.

IV. CONCLUSION

- The simulation of frontal car crash is characterized by impact modelling using solid works according to the speed 60km/hr and 90Km/hr given in order to analyse the results with the help of Ansys workbench.
- In this work the selected materials are compared to each other to find the best material with the strength and structure.
- From the results it is observed that in order to design car body two major factors considered. First the internal energy absorbed by the car body should be kept high by using the material having high yield strength and high modulus of elasticity.
- From the above analysis, that aluminium B390 alloy can reduce an impact collision with higher performance.
- The duration taken for Aluminum B390 alloy to deflect the impact was the shortest. compared to structural steel.
- It is concluded that the material Aluminum B390 alloy is good for the manufacturing of car body also because of its light weight and high anti corrosive property.

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